Sensor Defeat Tools

Mike Greene
Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV)
Code 5011A
2008 Stump Neck Road
Indian Head, MD 20640-5070
Phone: (301) 744-6952, x 225 Fax: (301) 744-6947
E-mail: greenem.eodtc@eodmgate.navsea.navy.mil

Document #: N0001499WX10013

LONG-TERM GOAL

The long-term goal of this task is development of technology that will enable EOD technicians safe access to Improved Explosive Devices/Special Improvised Explosive Devices (IEDs/SIEDs) for performance of a render safe procedure when protected by active infrared (AIR) type denial devices.

OBJECTIVES

The major objective of this task is to develop technologies and techniques for detecting and defeating area denial sensors to allow EOD technicians access to threat devices.

APPROACH

An AIR security device employs a transmitter, receiver, and a pulsed infrared beam. When the infrared beam between the transmitter and receiver is interrupted or broken, the AIR denial device enters an alarmed state. Transmitter and receiver may be a 1,000 feet apart or may be together within one unit.

The circuitry of the transmitter "pulses" the electronic beam many times a second to provide greater security and to minimize false alarms. Similarly, the receiver circuitry looks for these "pulses." Therefore, this technique minimizes the ability of an ordinary light source to trigger a false alarm in the receiver.

Our approach is to detect active infrared (IR) energy without breaking the beam between the transmitter and receiver. We will attempt to extend the performance of the exisiting tools by applying signal processing and energy collection techniques with more recent commercially available IR detectors. Our energy collection techniques will focus on the development of one or more wave guides to amplify the signal to noise ratio seen at the detector. Our signal processing improvements will focus on the use of autocorrelation and similar techniques. For example, two or more pyramid wave guides may be used side by side and/or one atop the other because of their small size. If the signals from a pair of pyramid wave quides are labeled A and B, the signal may be added electronically to increase the signal to noise ratio of the combined signal.

Another approach would be to multiply signal A by signal B to increase the signal to noise ratio. The procedure should have the same or similar results as the use of an autocorrelation technique. Here, the signals may have to be digitized before they are multiplied together.

The investigator will analyze the potential configurations and determine the best circuitry and energy collection techniques, which will enhance the signal to noise ratio and therefore increase detection ranges. The proposed circuitry will be breadboarded and tested. Because of the avialability of numerous types of signal processing chips, miniaturization of the tested circuitry should not be a problem. Laboratory test beds with pyramid type reflectors and signal processing means will be assembled and tested.

WORK COMPLETED

Presently, the approved technology to pick up the AIR signal remotely is accomplished with optoelectronic sensors mounted on a wand that is placed in the path of the AIR beam. However, a small prototype wave guide that is comprised of four sides in the form of a pyramid to focus IR energy onto a 300 series photodiode that is part of a commercially-off-the-shelf (COTS) detector was developed at NAVEODTECHDIV. The wave guide is described in a Disclosure of Invention that was assigned Navy Case Number 79557 on 21 October 1998. The sides of the pyramid are fabricated of acrylic sheeting with an interior surface that has a first/front surfaced mirror thereon. The length of the pyramid is approximately 11 inches. The front aperture is approximately 1.80 x 1.80 inches square; the rear, 0.25 x 0.25 inches square. The photodiode is mounted at the rear aperture. An important feature of this arrangement of wave guide and detector is the ability of the wave guide to shield the detector from the sun under certain conditions.

Florida Agricultural and Mechanical University/Florida State University (FAMU/FSU) received a grant for $80K from ONR in FY99 to improve the signal processing of this device in accordance with guidance outlined in the aforementioned Disclosure of Invention. FAMU/FSU utilized National Instruments' Laboratory Virtual Instrument Engineering Workbench (LabVIEW) software, Version 5.1, to analyze real time AIR signals from prototype/test bed AIR receivers and wave guides that were developed at NAVEODTECHDIV. A National Instruments' 12-bit A/D converter board, PCI 6023E, first digitized the analog signals from these prototype AIR receivers. The digitized signal was subjected to filtering or digital signal processing (DSP). Numerous meetings were held with Professor Gupta, the chief technologist and POC at FAMU/FSU, during this effort. Under Professor Gupta's tutilege, Mr. Ashish Trivedi published his thesis entitled, *Receiver for Identifying Characteristics of a Weak Pulse Modulated Infrared Signal.*

A mathematical analysis at NAVEODTECHDIV was conducted in FY99 to determine the optimum length of the pyramid. The results of the analysis showed the length should be shortened from the rear aperture.

A second prototype was constructed as shown below in Figure 1. This prototype employed a shorter wave guide in accordance with the above mathematical analysis. In addition, Professor Gupta from FAMU/FSU suggested mounting the COTS infrared detector with its photodiode attached – not mounted with a coaxial cable as in the original prototype/test bed. The former setup was most useful for testing various optoelectronic sensors in combination with the wave guide. Tests were conducted

with the shortened wave guide and directly attached COTS receiver to gather data. Later, limited field testing was undertaken during field exercises with EOD technicians.

Figure 1. FY99 Fabricated Prototype (Second) AIR Detector

A review of the work that included the aforementioned mathematical analysis completed in FY99 and demonstration of the second prototype AIR detector was presented at a NAVEODTECHDIV Research and Development (R&D) Review of 19 August 1999. Additional suggested methodologies for increasing illuminance of the incoming light were suggested during the review. As a result, a modified wave guide was assembled and evaluated with a Hamamatsu Photosensor Amplifier, Model C6386, and an Edmund Scientific (Part Number J41,806) concave unprotected gold mirror of 32 mm in diameter with a focal length of 25 mm. In addition, a second Hamamatsu Photosensor Amplifier, Model C2719, was assembled with a shortened wave guide in accordance with the mathematical analysis above and tested.

The Defense Technical Response Group (DTRG) reviewed accumulated data from tests of the second prototype and requested fabrication of units for field use. A preproduction unit that was based on the second prototype and additional requirements was fabricated in FY00 and is shown below in Figure 2.

FY01 plans were developed for further 6.2 investigation at NAVEODTECHDIV to increase AIR signal detectection. Preliminary tests with Fresnel lens and the original prototype detectors with shortened wave guides show this approach to be positive.

FRONT SIDE BACK

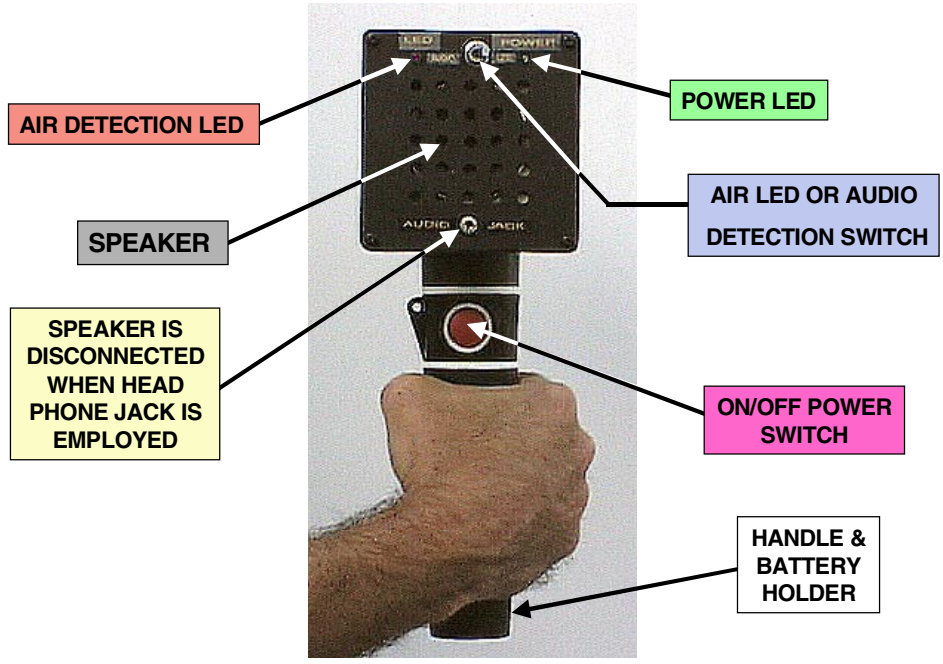

Figure 2. Pre-Production AIR Detection Unit

RESULTS

Tests conducted with the second prototype exceeded exectations in range and noise rejection. In addition, the second prototype was tested against actual targets during an FY99 Impact Exercise in San Diego during April 1999.

The mathematical analysis showing increased illuminance with the use of a shorter wave guide is available.

The preproduction prototype was utilized during EOD Mobile Unit 5 Training in Guam during June 2000. This tool received favorable comments from the trainees.

At FAMU/FSU, Mr. Trivedi used National Instruments' Laboratory Virtual Instrument Engineering Workbench software, Version 5.1, to analyze real time AIR signals from prototype AIR receivers that were developed at NAVEODTECHDIV. A National Instruments' 12-bit A/D converter board, PCI 6023E, first digitized the analog signals from protype AIR receivers. The digitized signal was subjected to filtering or digital signal processing (DSP). The DSP filtering resulted in an improved signal to noise ratio. DSP correlation techniques were also tried, but failed to improve the signal to noise ratio. Mr. Trivedi's thesis was reviewed at NAVEODTECHDIV during FY00.

IMPACT/APPLICATION

The impact on systems applications will be that EOD technicians will have new tools to use against area denial devices that utilize AIR. These technologies will allow EOD technicians to defeat sensors in less time and in a safer manner than previously possible.

Because of the greatly increased range sensitivity of the wave-guide type detector, detection may be accomplished at greater distances with the user at further distances from harm's way.

TRANSITIONS

Transitions from this task have been and are expected to continue to the Defense Technical Response Group. The DTRG provides electronic sensor detection equipment to Expolsive Ordnance Mobile Unit Five (EODMU5), Santa Rita, Guam and Explosive Ordnance Mobile Unit Eight (EODMU8), Sigonella, Italy.

RELATED PROJECTS

This work is synergistic with the Technical Support Working Group (TSWG). Work in the EOD Technology Plan is reviewed by the TSWG program manager for incorporaion into work for other federal agencies.

Bechtel's Remote Sensing Laboratory at Nellis AFB is working on an improved AIR detection device employing a zoom lens system.

PUBLICATIONS

Trivedi, Ashish N. 2000. Receiver for Identifying Characteristics of a Weak Pulse Modulated Infrared Signal. Florida Agricultural and Mechanical University/Florida State University Library.

PATENTS

Greene, Michael, Naval Explosive Ordnance Disposal Technology Division (NAVEODTECHDIV). Patent Invention Disclosure, Navy Case Number 79557; Active Infrared (AIR) EOD Security Device. A Record and Disclosure of Invention form was signed by Michael Greene on 24 Feb 98 and forwarded to the NAVSEA Patent Counsel. The case has since been transferred to the Office of Counsel, Naval Surface Warfare Center, Indian Head. Additional improvements regarding advancements in the art of AIR detection with a pyramid wave guide detector have been documented and forwarded to the Office of Counsel.